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ABSTRACT

The role of the science teacher is essential in determining the quality of the school science program. When teachers are aware of the relationship between science and society, they can relate classroom learning to practical application. This results in more positive student attitudes. The continuous evolving of scientific knowledge requires teachers to keep up with the latest developments in order to provide current information and experiences for their students. This paper reports on a program that was developed to help teachers facilitate learning and transfer scientific knowledge, experiences, and attitudes to their students. The 23 participants involved in the program reported that the program had increased their: (1) knowledge about research and application of science and mathematics outside the classroom; (2) awareness of the relationship of subject matter to industry and careers; and (3) interest in research and applied science. Included is an introduction, a description of the program, instrumentation and method, analysis, results, discussion, and references. Presented tables include program effects on participants and participants' confidence, results of tests comparing frequency of teaching activities before, and one year after, the program; and the impact on research and demonstration activities. Also listed are relevant items from the posttest and follow-up evaluation. (RT)

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The Effect of Active Research Involvement on Secondary Science and Mathematics Teachers

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The Effect of Active Research Involvement on Secondary Science and Mathematics Teachers

Introduction

Strengthening the science programs in American public schools has been an educational goal for over three decades, one that still exists. The role of the science teacher in determining the quality of the school science experience cannot be minimized. Relating classroom learning to practical application, (through activities such as class visits to science and/or technology museums), results in more positive student attitudes (Finson & Enochs, 1987), but this can occur only when the teachers are sensitive to the relationship between what is happening in their classrooms and the world around them. Scientific knowledge is continually evolving, creating the need for on-going educational experiences for science teachers if they are to keep abreast of the latest developments and procedures and be in a position to provide current information and experiences to their students.

The National Science Teachers' Association (1984), in its recommended certification standards regarding research skills, indicated that science teachers should be prepared "to conduct or apply, understand, and interpret science and/or science education research and to communicate information about research to others (e.g., students, teachers, and parents)." (p. 207). It is not enough to merely expose science teachers to new ideas related to their teaching area, there should be some expectation that the new

knowledge will make changes in the behavior of the teacher that will ultimately result in positive benefits for the students.

Good teachers are probably intrinsically motivated to keep up to date with developments in their fields through such means as professional activities. Teachers of exemplary science programs participate more actively in professional organizations and make presentations more frequently than other science teachers (Penick, Yager, & Bonnstetter, 1986). In comparing most effective and least effective science teachers, most effective teachers had attended more in-service workshops sponsored by the National Science Foundation (NSF) and had taken advantage of more elective in-service opportunities, thus promoting their own professional growth (Yager, Hidayat, & Penick, 1988).

The duration of professional development activities is also related to their impact. The length of time spent in staff development workshops has been found to be related to the intentions of the participants to apply the content in their classrooms (Bowyer, Ponzio, & Lundholm, 1987). Larger percentages of participants in longer workshops intended to apply the content to their teaching than participants in workshops of shorter duration.

A program was developed by the Oak Ridge (TN) Associated Universities (ORAU), the University of Tennessee, Knoxville (UTK), and the UTK Science Alliance to facilitate learning and the transfer of scientific knowledge, attitudes, and experiences to the

classrooms of public school science and mathematics teachers. The Science Alliance includes the science departments at UTK and several major organizations in the Oak Ridge area that are actively involved in scientific research.

The STRIVE Program

The Science Teachers Research Involvement for Vital Education (STRIVE) program was initiated in the summer of 1986. The program is sponsored by the National Science Foundation's Directorate for Science and Engineering Education through an interagency agreement with the U.S. Department of Energy and is administered by ORAU. The goal of the program is to improve the quality of education for public school students by enhancing the professional competence of science and mathematics teachers. This was accomplished by directly involving selected teachers in national science and engineering research and development (R&D) programs and by supporting other activities that enable teachers to interact with the region's leading research professionals. The program was designed to create a better understanding of how scientific knowledge is applied in a laboratory environment.

Participants were selected by the project staff from among those science and mathematics teachers submitting applications. Participants were employed for eight weeks during the summer to serve as full-time researchers in well established R & D projects, becoming integral members of research teams and involved in all aspects of the research process. Each participant was supervised

by a senior scientific staff member (research mentor) at a major public or private research facility in the Oak Ridge area. Participants were assigned individually, and the nature of their activities varied according to the type of research being performed and the needs of the research agency in which they were located.

Participants also spent one day each week in workshop sessions designed to facilitate the transfer of their research experiences to teaching activities through development of materials and plans for units and activities. University resources for the development of classroom materials were made available to the participants. Outstanding researchers also made presentations and participated in seminars during the workshop sessions. Participants became familiar with resources (e.g., a statewide list of Visiting Scientists, Saturday Science Series programs for students in Oak Ridge) available during the school year.

The objective of this study was to determine the impact of the STRIVE program on participants (secondary school science and mathematics teachers).

Method

The 23 participants in the STRIVE program in the summer of 1987 and their school principals during the 1987-88 school year provided the data for this study. The group consisted of six males and 17 females with ages ranging from 28 to 56 years (mean = 41.4 years). Years of teaching experience varied from one to 32 years, with a mean of 12.7 years. Ten participants were working toward

advanced degrees, and 18 of the 23 already possessed degrees beyond the Bachelor's level. Seventeen (78%) were from Tennessee. Fourteen were certified to teach science courses, eight were certified in both science and mathematics, and one was certified in mathematics only.

Instrumentation

In the opening session of the beginning of the summer program all participants completed a four-page pretest. Items on the pretest were developed on the basis of project objectives. Frequency of teacher's use of various teaching activities was measured using a modified form of Weiss' (1977) chart, in which they rated the frequency of each activity as almost daily, at least once a week, at least once a month, less than once a month or never. They were also asked to rate their knowledge, understanding, awareness, interest, and confidence on ten items, using seven-point rating scales. (Items are included in Tables 1 and 2.) Participants were asked the numbers of students completing independent research and Science Fair projects during the 1986-87 school year and the percentages of time in their classes devoted to demonstration and laboratory activities. The Science Attitude Scale (Thompson & Shrigley, 1986) was used but is not reported in this part of the study.

At the conclusion of the summer, participants completed a four-page evaluation questionnaire (posttest). The questionnaire contained nine items pertaining to program effectiveness (increased

knowledge, understanding, awareness, and interest) and asked the participants whether or not participation in the program had affected them in each of the ways listed. They also rated their perceived knowledge, understanding, awareness, and interest on the seven items identical to those on the pretest and two additional ones related to their specific research topic.

In April, of the school year following participation in the STRIVE program, 20 of the 23 participants completed and returned follow-up evaluation questionnaires (follow-up). The questionnaire contained three items reflecting participants' confidence regarding science teaching and activities, and participants were asked to indicate whether participation in the program had caused an increase in each item. Participants also rated their level of confidence on four items on 7-point rating scales (three of the same items as appeared on the pretest). Items matching those on the pretest regarding percentage of time for laboratory and demonstration activities, number of students completing research projects, and frequency of teaching activities were asked for the 1987-88 school year.

Project staff reviewed all instruments prior to use to determine their applicability in light of program objectives and actual program activities.

Analysis

Frequency distributions were tabulated for items pertaining to participants' perceptions of their knowledge, understanding,

awareness, and interest on the posttest and of their confidence on the follow-up posttest. Paired t-tests were used to compare pretest and posttest ratings of knowledge, interest, understanding, and awareness. Paired t-tests were also used to compare pretest and follow-up ratings of participants' confidence, the numbers of students completing independent research projects and Science Fair projects under participants' supervision, and the percentage of time devoted to demonstration activities and laboratory activities by the participants. Sign tests were used to compare the frequency of classroom teaching activities on the pretest and follow-up. The .01 level was used for establishing statistical significance.

Results

On the posttest at the end of the summer, all participants reported that the program had increased the following (see Table 1):

- knowledge about research and application of science and mathematics outside the classroom
- awareness of the relationship of subject matter to industry and careers
- interest in research and applied science

All but one participant reported increases in five other areas of knowledge, awareness, interest, and understanding. The area with the least impact was understanding of the operation and function of the Department of Energy laboratories. Ratings increased on all 11 self-perception items. Participants' ratings on six of the seven

items for which pretest ratings were possible (all but the two pertaining to the project on which the participant worked), were significantly higher at the end of the summer than when participants began the program.

By the end of the school year following program participation, 70% or more of the participants reported increased confidence in teaching their classes, supervising student research projects, and discussing science and mathematics applications with students (see Table 2). Paired t-tests comparing the 7-point ratings with those from the beginning of the program supported the self-reported increases in confidence but not at significant levels.

Sign tests showed no significant differences in the frequency with which the participants utilized various teaching activities (see Table 3). Nonsignificant increases were noted in the average numbers of students completing independent and Science Fair research projects under the direction of the participants (see Table 4). There was, however, a significant increase in the percentage of time devoted to laboratory activities in the participants' classes. This was accompanied by a smaller decrease (nonsignificant) in the percentage of time devoted to demonstration experiments.

Discussion

Data indicate that the STRIVE program, actively involving public school science and mathematics teachers in on-going research participants during the summer had an impact on their perceived

knowledge, understanding, awareness, interest, and confidence. In addition the participants changed their teaching to increase the amount of time devoted to student laboratory activities. It is important to note that the data are based on self-perceptions of the teachers and not on observed behavior. The number of participants in the program is fairly small. At this time three groups have participated in the summer program. Although responses from the other two groups are not included, their reactions to the program have been consistent with those reported here.

Most of the participants reported having made changes in their teaching activities, although those changes did not make a significant impact on the types of activities (lecture, discussion, etc). (In a separate item, not included here, participants most frequently reported changing the content of their courses.) The categories used (in Table 3) may have been too broad for changes to have been detected.

Participants were already highly motivated, as shown by their participation in the program. Their initial levels of knowledge and confidence were high, thus it might have been difficult to achieve significant improvement. One individual commented at the end of the summer that although her ratings on knowledge might not indicate that she had learned a lot, she had become aware of how much more she didn't know.

While basing any conclusions solely on self perceptions is susceptible to individual interpretations of the items, it is

unlikely that all or nearly all of the individuals in the project would think that the program had benefited them in certain ways unless there had been some actual gains from the program.

In a separate survey, responses of the school principals of the participants validated their (participants') perceptions that the program had been beneficial for others in the school (peers and students) as well as the participants.

Direct involvement in relevant activities combined with workshops and facilitation by university faculty members can be used as a means of updating the knowledge and skills of practicing teachers (many of whom had extensive teaching experience) as well as increasing their confidence related to research, leading to increased opportunities for actual laboratory experiences for students.

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Table 1

Program Effects on Participants

Area	Increase reported		Rating means[a]		t	p[b]
	n	%	pre	post		
Knowledge about research and the application of science and mathematics outside the classroom	23	100	4.39	5.87	4.04	.001
Knowledge about the topic on which s/he worked	22	96	n/a	n/a	n/a	n/a
Knowledge about current scientific research and issues	22	96	4.74	5.75	2.87	.009
Understanding of the role of science in finding solutions to national problems	22	96	5.39	5.96	2.73	.012
Understanding of the operation and function of the national laboratories	18	78	4.00	5.52	4.58	<.001
Awareness of job opportunities and training areas in science	22	96	4.74	6.13	3.81	.001
Awareness of the relationship of subject matter to industry and careers	23	100	4.91	6.26	3.75	.001
Interest in research and applied science	23	100	6.43	6.78	2.91	.008
Interest in the topic on which s/he worked	22	91	n/a	n/a	n/a	n/a

NOTE: N=23

[a]Ratings based on 7-point rating scales with 1=low level or none, 7=high level

[b]Two-tailed test

Table 2

Program Effect on Participants' Confidence

Area	Increase Reported		Ratings means[a]			
	n	%	pre	post	t	p[b]
Confidence in teaching classes	14	70	6.60	6.75	1.14	.134
Confidence in discussing science and mathematics applications with students	19	95	6.45	6.64	1.07	.150
Confidence in supervising student research projects	16	80	5.55	6.10	2.24	.018
Confidence in interacting with peers on scientific matters	n/a	n/a	5.75	6.35	1.98	.031

NOTE: N=20

[a]Ratings based on 7-point rating scales with 1 = no confidence; 7 = very confident

[b]Two-tailed test

Table 3

Results of Sign Tests Comparing Frequency of Teaching Activities Before STRIVE Program and One Year Later

Activity	Participants			
	+	-	0	p
a. Lecture	4	1	14	0.187
b. Discussion	4	3	13	0.500
c. Student reports or projects	4	4	12	1.000
d. Individual assignments	4	7	7	0.274
e. Students use hands-on manipulative or laboratory materials	2	2	13	1.000
f. Computer-assisted instruction	2	4	13	0.344
g. Field trips, excursions	8	2	10	0.027
h. Guest speakers	4	1	15	0.182
i. Teacher demonstrations	4	3	13	0.500

Table 4

Impact on Research and Demonstration Activities

Research Activities	Mean		t	p
	1986-87	1987-88		
Number of students completing independent research projects under their supervision	44	55	0.74	.235
Number of students completing Science Fair projects	20	21	0.19	.425
Time devoted to laboratory activities	15.3%	18.3%	2.73	.007
Time devoted to demonstrations experiments	16.1%	14.2%	0.45	.330

7. Please evaluate other aspects of the STRIVE program on the following basis:
   1 = Needs improvement
   2 = Good
   3 = Very good

	NI	G	VG
a. Program administration	1	2	3
h. Advance communication	1	2	3
c. Availability of resources	1	2	3
d. Assistance provided by ORAU Project staff	1	2	3
e. University of Tennessee faculty members	1	2	3

8. In what ways has your STRIVE participation affected you? (Please check in the appropriate column beside each statement below.)

Yes	No	
____	____	1. The program increased my knowledge about research and the application of science and mathematics outside the classroom
____	____	2. The program increased my interest in research and applied science
____	____	3. The program increased my knowledge about the topic on which I worked
____	____	4. The program increased my interest in the topic on which I worked
____	____	5. I have a better understanding of the role of science in finding solutions to national problems
____	____	6. I have a better understanding of the operation and function of the DOE laboratories
____	____	7. I am more aware of job opportunities and training areas in science.
____	____	8. I am more aware of the relationship of subject matter to industry and careers.
____	____	9. I am more knowledgeable about current scientific research and issues.
____	____	10. I would recommend the program to other science/mathematics teachers
____	____	11. Knowing what I now know about the program, I would still choose to participate in the program.
____	____	12. Do you plan to apply to be a participant in STRIVE again in the future?

9. Please rate each of the following by circling a number from 1 to 7 to indicate your response.

a. Your knowledge about research and the application of science and mathematics outside the classroom
   No knowledge 1 2 3 4 5 6 7 Very knowledgeable

b. Your interest in research and applied science
   No interest 1 2 3 4 5 6 7 Very interested

f. Your understanding of the role of science in finding solutions to national problems
   No understanding 1 2 3 4 5 6 7 Thorough understanding

g. Your understanding of the operation and function of the national laboratories
   No understanding 1 2 3 4 5 6 7 Thorough understanding

h. Your awareness of job opportunities and training areas in science
   No awareness 1 2 3 4 5 6 7 Very aware

i. Your awareness of the relationship of subject matter to industry and careers
   No awareness 1 2 3 4 5 6 7 Very aware

j. Your knowledge about current scientific research and issues
   No knowledge 1 2 3 4 5 6 7 Very knowledgeable

STRIVE Project Follow-up Evaluation

Program Effect

In what ways has your STRIVE participation affected you? (Please check in the appropriate column beside each statement below.)

Yes	No	
____	____	1. I feel more confident in teaching my classes.
____	____	2. I feel more confident in discussing science and mathematics applications with my students.
____	____	3. I feel more confident in supervising research projects of my students.
____	____	4. I have drawn on my STRIVE experiences for explanations and examples in my teaching. class demonstrations, or laboratory exercises.
____	____	5. I have drawn on my STRIVE experiences as a basis for student independent research projects.
____	____	6. I have used STRIVE materials in teaching my classes or in working with student groups (Science Club, Math Club, etc.).
____	____	7. I have made presentations to student groups about my STRIVE experiences.
____	____	8. I have drawn on my STRIVE experiences in making inservice presentations to peers.
____	____	9. I have drawn on my STRIVE experiences in making presentations to parents and community groups.
____	____	10. I have shared my experiences and the knowledge from the program with colleagues in informal conversations.
____	____	11. I have shared STRIVE materials with colleagues.
____	____	12. I have made changes in my teaching based on my experiences in STRIVE.
____	____	13. The amount of time I devote to demonstration experiments in my classes has increased.
____	____	14. I present course content in relationship to scientific research to a greater extent now than in previous years.
____	____	15. I have recommended the program to other science/mathematics teachers.
____	____	16. I have recommended the program to others who are not science/mathematics teachers.

Specific Applications

____	____	17. Have you added any topics, units, or activities to the content of the courses you teach this year (1986-87)?
____	____	18. Have you had contact with your research mentor since the program concluded last summer?
____	____	19. Have you invited your mentor to visit your school?
____	____	20. Has your mentor visited your school?
____	____	21. Have you submitted or do you plan to submit any articles for publication as a result of your STRIVE participation?
____	____	22. Have you attended any of the Saturday morning science programs in the "Orders of Magnitude" series conducted at the American Museum of Science and Energy in Oak Ridge?
____	____	23. Have you taken students to any of the Saturday morning programs or encouraged students to attend on their own?
____	____	24. Have you invited any of the scientists listed among the Visiting Scientists to make presentations at your school this year?
____	____	25. Have you received follow-up information or related program materials from STRIVE since last summer?

Yes No

____ ____ 26. Have you requested additional financial support or resources from your school or district administration for implementing new units, courses or projects as a result of STRIVE?

____ ____ 27. Have you received additional financial support or resources from your school or district administration for implementing new units, courses or projects as a result of STRIVE?

Ratings. Please rate each of the following by circling a number from 1 to 7 to indicate your response.

a. Your confidence in teaching your classes
No confidence 1 2 3 4 5 6 7 Very confident

b. Your confidence in discussing science/mathematics applications with your students
No confidence 1 2 3 4 5 6 7 Very confident

c. Your confidence in supervising research projects of your students
No confidence 1 2 3 4 5 6 7 Very confident

d. Your confidence in making presentations at inservice meetings
No confidence 1 2 3 4 5 6 7 Very confident

e. Your confidence in interacting with peers on scientific matters
No confidence 1 2 3 4 5 6 7 Very confident

General Information

1. Approximately how many students are enrolled in your science/mathematics courses this year? ____

2. Approximately how many students completed independent research projects (or are expected to complete them before the end of the school year) under your supervision during this school year? ____

3. Approximately how many of your students completed projects for your local Science Fair during this school year?
____

4. Approximately what percentage of the time in your science/mathematics classes is devoted to:
a. laboratory activities ____%
b. demonstration experiments ____%

5. Has there been any change in the percentage of time devoted to laboratory activities in your classes from 1986-87?
____1. Yes, an increase
____2. Yes, a decrease
____3. No

6. How does the number of students who are doing or have completed independent research projects under your supervision this year compare with the numbers in previous years?
____1. More students are doing research projects this year
____2. Fewer students are doing research projects this year
____3. About the same number of students are doing research projects this year

7. How does the number of your students doing projects for the local Science Fair compare to the number who did them in 1986-87?
____1. More of my students are doing Science Fair projects this year
____2. Fewer of my students are doing Science Fair projects this year
____3. About the same number of students are doing Science Fair projects this year